Space Weather Technical Forecast

Issued on Thursday, 07 December 2023 at 13:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of further isolated M-Class flares (R1-R2 Blackouts) throughout. Active fluence likely from days 2-4 (08-10 Dec).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity is currently Moderate with a single M-class with a peak M2.3 at 06/2144 UTC, which originated from AR3513 in the northeast. There are currently nine sunspot regions on the visible disc. The most active region on the disc is AR3513 in the northeast. The viewing angle of this region is improving, showing some magnetic complexity. Two moderately large sunspots in the southwest, AR3510 and AR3511, are part of a complex of groups in this area, with magnetic connection between these regions. The spots appear to be spreading longitudinally with some reduction in areal extent. AR3507 in the northwest has more of a north-south magnetic alignment, perhaps increasing instability. The other regions on the disc appear mostly smaller and simpler at present.

A number of CMEs have been evident in coronagraph imagery during the past 24 hours. Although none are currently deemed to have any Earth-directed component, further imagery and analysis is required to confirm this.

Solar Wind / Geomagnetic Activity: Solar winds as measured by ACE and DSCOVR at L1 show an ongoing but waning High Speed Stream (HSS) from coronal hole CH76/-. Wind speeds were elevated, around 570km/s but have gradually fallen back to slightly elevated levels, around 490 km/s during the period. Density has been below average throughout. The Interplanetary Magnetic Field (IMF), Bt, has been weak throughout at 5nT or below. The north-south component of the IMF (Bz), has varied weakly. Phi angle has been predominantly negative (towards the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux remained at background levels. GOES16 high energy (greater than 2MeV) electron flux was at moderate levels. The associated 24-hour fluence has remained below the Active threshold (1e8 integrated pfu), but with an upward trend. The observation at 07/0000 UTC was 2.52e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low to Moderate with a chance of further isolated M-class flares, mainly from AR3513, but perhaps also AR3510, AR3511 or AR3514.

Solar Wind / Geomagnetic Activity: No Earth directed CMEs currently feature in the forecast. Solar winds are currently at slightly elevated levels (around 490 km/s) due to waning effects from a coronal hole HSS. Solar winds are expected to continue to decline through the coming days, becoming background on day 3 (09 Dec). On day 4 (10 Dec), the fast wind from a new coronal hole is expected to arrive, with speeds increasing to, or close to elevated levels.

Geomagnetic activity is expected to be largely Quiet through days 1-3 (07-09 Dec) with a chance of isolated Unsettled intervals. On day 4 (10 Dec), the arrival of a coronal hole HSS should bring Unsettled to Active (Kp3-4) periods with a very slight chance of a G1/Minor Geomagnetic Storm interval (Kp5).

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

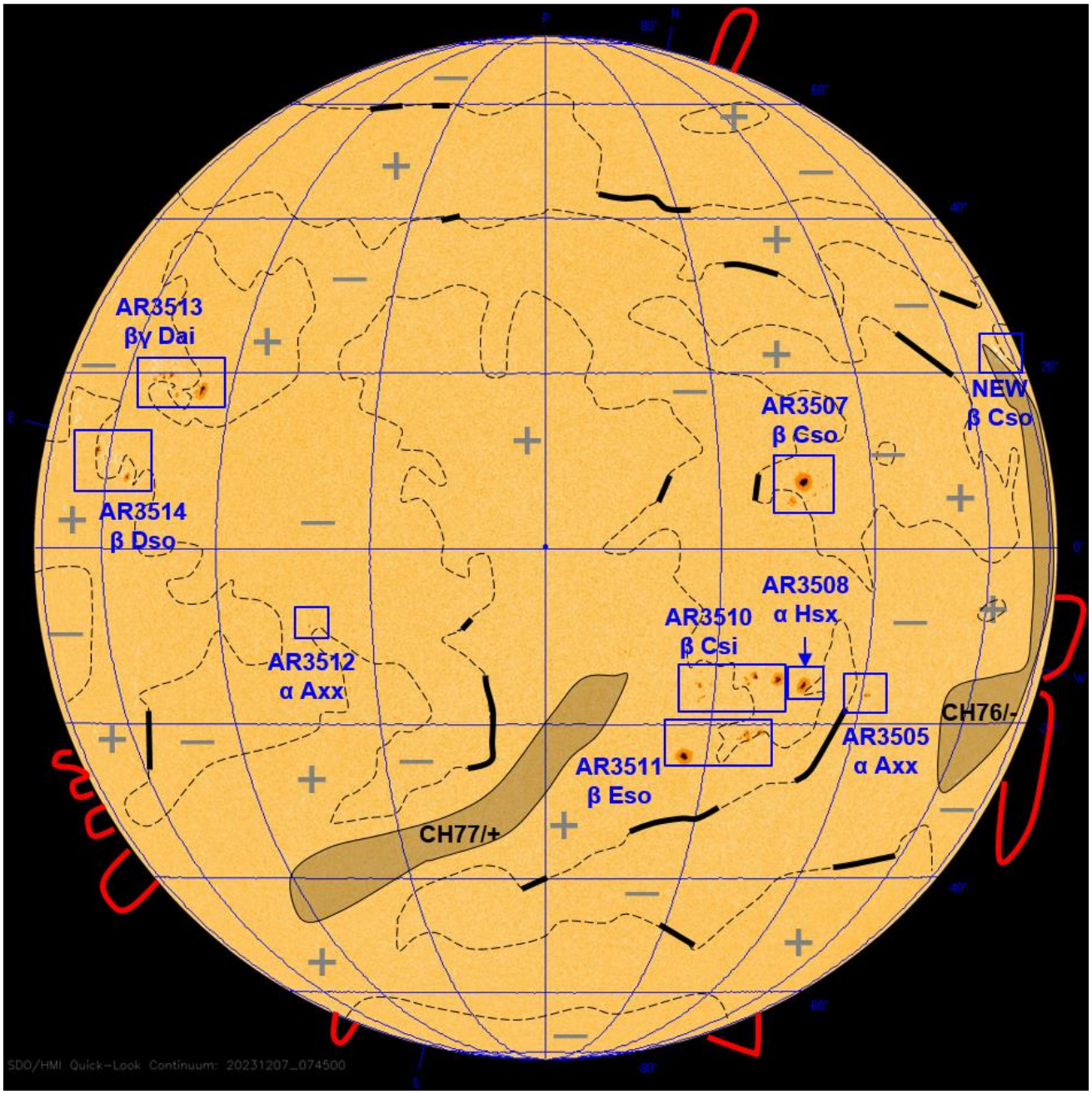
Energetic Particles / Solar Radiation: GOES16 high energy proton flux is forecast to remain at background levels, with just a very slight chance of reaching the S1/Minor Storm level should there be any larger flares from the sunspot regions in the western hemisphere.

Electron flux is currently at moderate levels. An increase in electron flux, reaching high levels at the diurnal maxima is likely through the forecast period until the expected arrival of the HSS from a coronal hole on day 4 (10 Dec) results in a suppression in counts once again. The associated 24 hour electron fluence is expected to increase through the coming days, likely exceeding the Active (1e8 integrated pfu) threshold days 2-4 (08-10 Dec).

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 1. Solar Analysis Valid 07/0745 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Geomagnetic Storms:

The forecast arrival window for a CME produced by a filament eruption around 04/0700 UTC has now likely passed. Otherwise, there have been various filament eruptions on the Earth-facing disc in the past several days. A filament eruption from north-centre disc around 06/0500 UTC appears to have been largely reabsorbed, however, a narrow, faint CME can be seen in coronagraph imagery emerging around 06/0800 UTC that could be associated with this event. This is not expected to be Earth-directed, although further analysis will take place to confirm this. A second filament eruption took place around 07/0200 UTC. Coronagraph imagery indicates that a CME resulted from this, emerging to the northeast in LASCO C2 imagery around 07/0300 UTC. It is unlikely there is any Earth-directed component, but analysis and modelling is still required for this event.

Solar winds are currently at slightly elevated levels (around 490 km/s) due to waning effects from CH76/-. Solar winds are expected to continue to decline through the coming days, with speeds likely to be near background levels during day 3 (09 Dec). On day 4 (10 Dec), the fast wind from CH77/+ is expected to arrive, likely bringing elevated winds speeds (500-550km/s) at peak, though this probably just outside the scope of the current forecast period at this time. The leading edge of this feature is fairly narrow and therefore the timing of the onset of this feature is somewhat lower confidence than usual. On the previous rotation similar speeds to what is forecast were observed. Enlil is currently providing good guidance on wind speeds.

Geomagnetic activity is expected to be largely Quiet through days 1-3 (07-09 Dec) with a chance of isolated Unsettled intervals. On day 4 (10 Dec), the arrival of CH77/+ should bring Unsettled to Active (Kp3-4) periods with a very slight chance of a G1/Minor Geomagnetic Storm interval (Kp5).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	1	1	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections - Nil

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

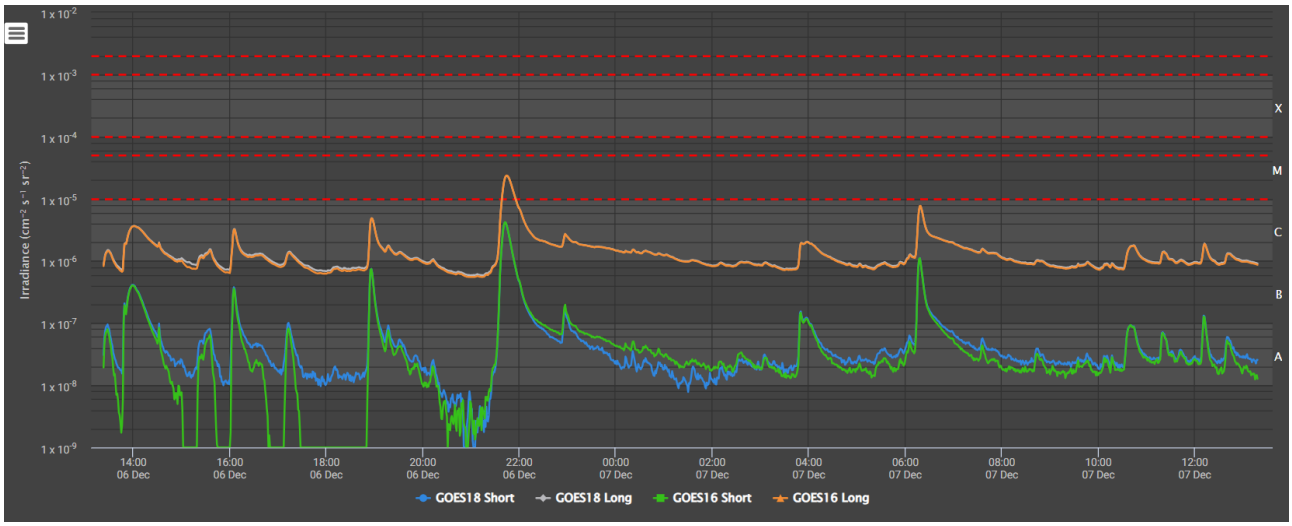
© Crown Copyright 2023. All Rights Reserved.

Radio Blackouts - X-Ray Flares:
There are currently nine sunspot regions on the visible disc. The most active region on the disc is AR3513 in the northeast. The viewing angle of this region is improving, showing some magnetic complexity with a Beta-Gamma Mount Wilson classification. Two moderately large sunspots in the southwest, AR3510 and AR3511, are part of a complex of groups in this area, with magnetic connection between these regions. The spots appear to be spreading longitudinally with some reduction in areal extent. AR3507 in the northwest has more of a north-south magnetic alignment, perhaps increasing instability. The other regions on the disc appear mostly smaller and simpler at present.

Solar activity is currently Moderate with the largest flare of the past 24 hours an M2.3 event at 06/2144 UTC, which originated from AR3513. Low to Moderate activity is expected to continue with a chance of further isolated M-flares, mainly from AR3513, but perhaps also AR3510, AR3511 or AR3514. No significant regions are expected to rotate off the disc in the next four days, and far side seismographs are not showing any large regions due to rotate onto the disc. As such, the flare probability has been kept flat through the next few days.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	50	50	50
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 2: GOES 16/18 X-ray Flux



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is currently at background levels and is most likely to remain so in the next few days. There is a slight chance of S1/Minor Storm conditions being reached should any significant flares occur, mainly from AR3510 and AR3511 as they rotate further across the western disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

Electron flux is currently at moderate levels. The Van Allen belts are now relaxing as the suppressing effects from CH76/- wane. An increase in electron flux, reaching high levels at the diurnal maxima is likely through the forecast period until the expected arrival of the HSS from CH77/+ on day 4 (10 Dec) results in a suppression in counts once again.

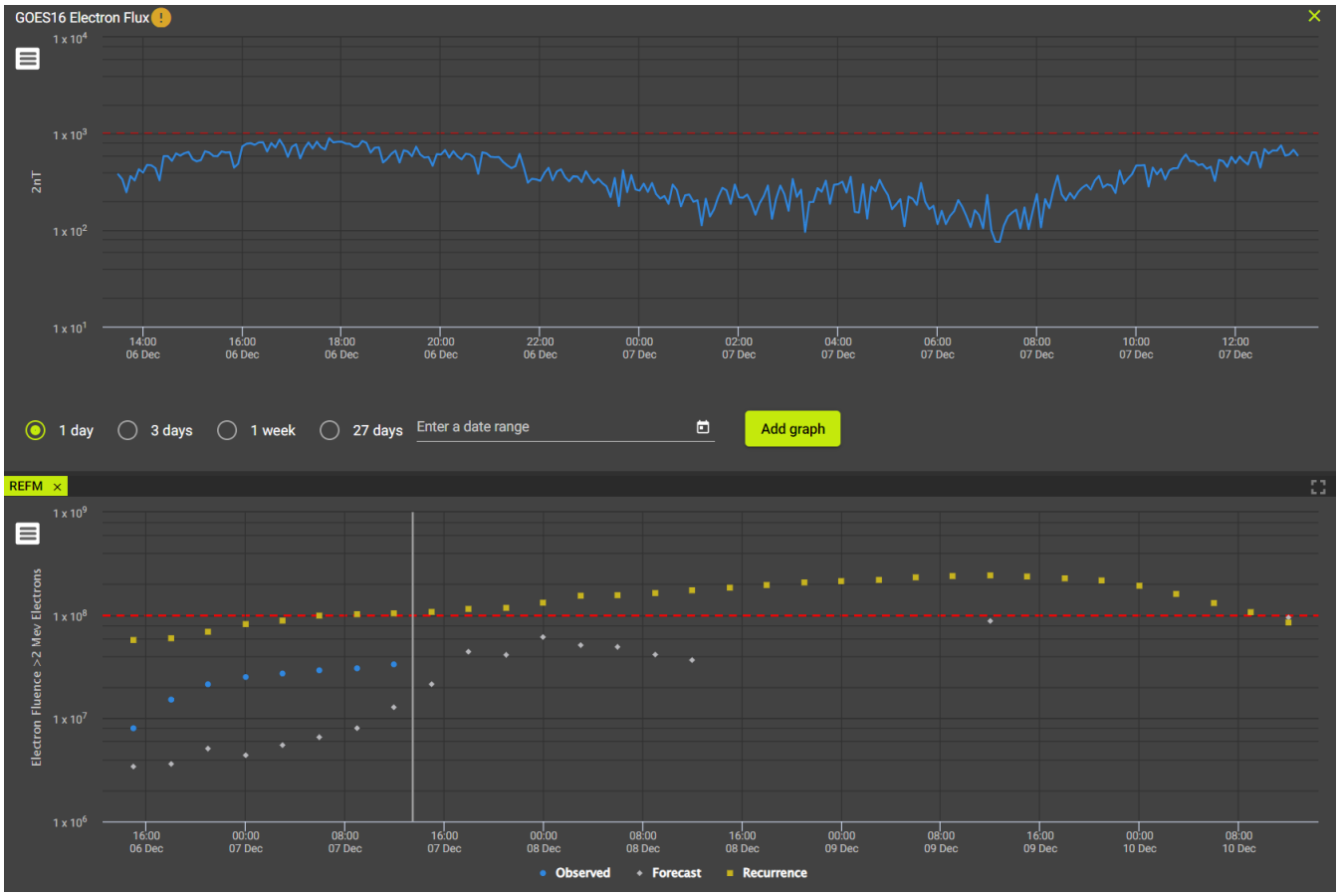
The associated 24 hour electron fluence is expected to increase through the coming days, likely exceeding the Active (1e8 integrated pfu) threshold days 2-4 (08-10 Dec). REFM is considered to be providing reasonable guidance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	5	60	80	80
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 3: >2MeV GOES16 Electron flux (above) and MOSWOC REFM forecast and Recurrence (below)



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.